A STUDY OF THE TWIG BORER XYLEBORUS MORIGERUS BLANDFORD, MAINLY BASED ON OBSERVATIONS IN JAVA *)

by

L. G. E. KALSHOVEN

Blaricum, The Netherlands

Historical

In 1891 in a hot-house at Bath, England, orchid plants were found damaged by minute boring beetles; the plants had been received from New Guinea earlier, at which time the infestation had remained unnoticed. The beetles were examined by W. F. H. Blandford, lecturer in Entomology at the Royal Indian Engineering College, London who recognized the species as a *Xyleborus,* apparently new to science and of tropical origin. He described his new species in 1894 in "Insect Life", a periodical issued by the U.S. Department of Agriculture, as *Xyleborus morigerus.*

In the beginning of 1896 a similar infestation was observed in the hot-house of an orchid grower in Marseille, where the plants originally had been obtained from a London horticulturist. Dr. A. Chobaut studied the case and submitted the beetles to Blandford who found them identical with his species.

In a private letter written in French and dated 22 April, 1896 (which I happened to find in a copy of "Insect life" from an antiquarian), Blandford states that since 1891 three or four similar infestations had come to his attention in England, and that the insect was apparently spread by the horticulturists.

In a short paper Chobaut (1897) gives a description of the initial stages of the insect and observes that the infestation had already been noticed also in Italy.

In November, 1906, a small brown borer was found killing the twigs of *robusta* coffee on an estate on the slopes of Mount Kawi in East Java, and in the beginning of 1907 the same infestation in a more severe degree was encountered with on two estates near Salatiga in Central Java (Wurth 1907, Anon. 1907 a, b, Hunger 1907).

It was soon evident that the twig borer infestation was spreading very rapidly and an annual report for 1907 stated that apparently only a few *robusta* plantations were still free from the attack (Hunger 1908). In the same year the borer was brought to the attention of the Department of Agriculture at Bogor (Cramer

*) The preparation of this paper has been much facilitated by a grant received from the Netherlands Organization for the Advancement of Pure Research (Z.W.O.).

1908). WURTH published a comprehensive paper in 1908, including the description of the insect and a parasite, with development stages of both. He concluded that the borer was not identical with a twig borer found in 1891 in hybrid coffee in West Java by ZIMMERMANN, basing his opinion on literature data as no specimens were apparently available for comparison. As has been recently proved, ZIMMERMANN's borer is identical with the black twig boring species, *Xyleborus morstatti* Hag. (KALSHOVEN 1959 b). No fitting description being available, WURTH considered his species as new to science and named it *Xyleborus coffeae.*

A small pinhole borer killing seedlings of mahogany in forest plantations in Central Java was first reported in 1915. The present author, starting his incidental observations in 1918, found that the beetles were identical with the brown coffee twigborer, but specimens sent in 1924 to F. WINN SAMPSON in London were identified with *X. morigerus* Bldf. Therefore the name *X. coffeae* was dropped as a synonym. I published an account of the occurrence of the borer in forest plantations in 1926.

Incidental observations on the varying prevalence of the brown twig borer in the coffee plantations in Java continued since 1910. In 1925 the borer became a subject of more intensive and systematic investigations at the Experiment Stations in East Java, though at that time the coffee berry borer, *Stephanoderes hampei*, was the main item on the entomologist's work programme.

In 1928 twig borer damage to *robusta* plantations began to attract attention again; they were of increasing incidence in subsequent years. However, this apparently was exclusively due to the invasion and rapid spread of the black species, *X. morstatti*, in Central and East Java (KALSHOVEN 1958 b). Extensive investigations carried out in the years between 1930 and 1938, mainly by J. G. BETREM, dealt in the first place with the black species. However, his study covered many points of the ecology of the twig borers and the susceptibility of the host plant to attack, which are of equal interest for the study of *X. morigerus.*

PRIMARY OCCURRENCE OF THE BORER IN ITS PRINCIPAL HOSTS

1. *Orchidaceae*

The orchid plants which harboured the type specimens of BLANDFORD (1894) were *Dendrobium phalaenopsis* Fitzg. This plant is, since long, a favorite of the orchid breeders. For further details on the early occurrence of the borer in orchids shipped to different parts of the world see WICHMANN (1954) and SCHEDL (1942 a, 1955).

In Java the borer, identified as "the very small *Xyleborus* species also attacking coffee", was first reported from orchids in 1909 by the Hortulanus of the Botanic Gardens of Bogor, particularly in the stems of *Dendrobium phalaenopsis* and *D. urvellei* Finck. The infestation had killed vigorous plants in a few months time (WIGMAN, 1909).

Since that date material of *Xyleborus*-infested orchids was received at the In-

stitue for Plant Diseases and Pests at Bogor a few times from different places in Java.

FRANSSEN & TIGGELOVEND (1935) dealt with this infestation by *X. morigerus* and *X. morstatti* in a special paragraph. However, they gave only a combined list of species attacked by one or both. According to this record various *Dendrobium* species are mainly attacked, *D. phalaenopsis* and *D. veratrifolium* Lindl. being preferred. Furthermore the thick, fleshy aerial roots of various *Vanda* species, like *V. coerulea* Griff. and *V. tricolor* Lindl. are often infested, as occasionally also *V. teres* Lindl. and *Cattleya* species.

No data on the size of the broods in orchids in Java are available, but there is a note on the occurrence of the borer in *Dendrobium superbiens* Rehb. F., recently imported into Hawaii from Australia (SWEZEY 1935); the data mentioned here are reproduced in the table on p. 106 below.

2. *Coffea* species

Th. WURTH, a Swiss botanist on the staff of the Experimental Station at Salatiga, discovered the coffee twig borer in Java in 1906. He particularly studied the comparative susceptibility of the main *Coffea* species to diseases and pests. Originally *C. arabica* ("Java coffee") had been cultivated on a large scale, but owing to the ravages of the destructive leaf fungus *Hemileia vastatrix,* this species had been first replaced by *C. liberica*, imported about 1880, and later by *robusta* coffee. The latter type, now considered to belong to a group of varieties and forms including the "quillou coffee" and the "Uganda coffee", is related to *C. canephora* Pierre; it originates from Africa and has become available on the market in 1900, at what time it appears to have been introduced also in Java; the first crops of some extent were not obtained before 1909 (VAN HALL 1912). WURTH failed to find the twig borer on *C. arabica* and *C. liberica* and did not succeed in rearing the beetle on living branches of these species nor on their hybrids (WURTH 1908, p. 7 and 12). However, according to a planter, the borer had been found in plantations of Liberia coffee earlier (ANON. 1907 b). This is confirmed by a specimen of *X. coffeae* Wurth (det. EGGERS) which I have seen in the Zoological Museum at Bogor, labelled: "holl.-Indien 1902 P. Omboh". The locality stands for the Petung Omboh Estate on the slopes of Mount Smeru in East Java.

In July, 1915, the borer was observed in "Uganda coffee" at the experimental garden Sumber Asin near Turen, South of Malang. In the same year a severe attack on *C. excelsa* Chev. was reported at an estate near Wlingi, Kediri District, East Java (WURTH 1916, p. 18). This species of coffee was grown to a small extent only.

Most reports of attacks of *robusta* coffee trees refer to the occurrence of the borer in the fruit-bearing, plagiotropic branches as well as in the orthotropic branches. The latter, thicker and more sappy, appear to provide a better breeding medium. The borer has also been observed in sapling trees of 2 years and upwards, in suckers of pruned plants, in stumps used for planting, and in grafts (BLEY 1907, ANON. 1927 p. 27).

Plagiotropic branches are also attacked in the flowering stage and often the

borer holes and the infestation with the ambrosia fungus, and probably also with other organisms, cause the death of the terminal part or of the whole branch, disturbing the flowering (KEUCHENIUS 1915, 'Bloeimislukking'), or the ripening of the berries. Orthotropic parts of the plants are not killed so readily.

There exist two records of the brown twig borer boring in fruits. LEEFMANS (1923 p. 49) in his *Stephanoderes* paper wrote: "It is curious that during examinations of coffee beans ready for the market and originating from Central Java, dead specimens of *Xyleborus coffeae* Wurth were repeatedly found. The beetles apparently bored into the fruits at the time they were still attached to the tree."

In 1927 a specimen of a small variety of *X. morigerus* was found in a sample of berries received from an estate in North Celebes where twig borers were rampant. From the same sample two specimens of the black twig borer, *X. morstatti*, were extracted (LEEFMANS 1928, KALSHOVEN 1958 b).

3. *Theobroma cacao*

Artificial infection of small cacao plants with the brown coffee twig borer was already accomplished by WURTH in 1908. Soon afterwards a natural infestation was found in two months old plants at a nursery near Salatiga (July/August 1909). The infested plants were removed systematically and in the first six weeks the attack amounted only to 1%. In all the investigated plants the hole had been bored just at the root collar and had caused their death. The galleries were running in the soft pith of the stems. No infestation was observed at the same time on nearby nurseries of *robusta* coffee (DE LANGE 1909).

ROEPKE in 1917 (p. 148) stated in his notes on the Scolytidae of the cacao tree that primary attack occurred very rarely. There is only one record of such occurrence in more recent literature, viz. in branches of cacao trees at an estate in the Gunung Kidul District, South of Malang, in 1938 (ANON. 1939, p. 113).

4. *Thea sinensis*

First records of a small *Xyleborus* species (1 mm) attacking tea seedlings on nursery beds at two estates in West Java were published in 1919 (BERNARD, ANONYMOUS, p. 121).

In January, 1925, the Institute for Plant Diseases and Pests at Bogor received infested tea seedlings from nursery beds, two years and six months old, from Pamanukan and Tjiasem Estates near Subang, West Java. I identified this borer with the species already known from coffee and mahogany. GARRETSEN (1926) mentioned this case briefly. Another case was submitted to the Experiment Station, Malang, East Java, in 1926 (BEGEMANN 1927, p. 285).

In August, September and November, 1929, a similar infestation of tea seedlings was reported, apparently independently, from six localities, viz., one estate in Central Java and five plantations in West Java. VERBEEK (1930 a, b) published an account of these cases mainly based on the material received from Pangledjar Estate near Sumedang.

The particulars on the infestation of tea seedlings given by BERNARD and VERBEEK agree in most respects with my own, so far unpublished notes of 1925. They may be summarized as follows. The nursery plants are attacked in the base

of the stem, at the root collar and in the tap roots, up to 30 cm beneath the ground level. The wood of the stems is rather hard and the tunnels are mostly horizontal and circular, cutting through the wood cylinder and broadened to brood chambers. In some cases they may be vertical with short horizontal extensions in the core. Stems varying in diameter from 0.5—2 cm may be attacked. The tap roots of the seedlings are often more or less swollen, 1.3—1.5 the diameter of the stem; the tissue of the roots is somewhat spongy or turnip-like. Here the brood chambers are rather shaped like irregular long galleries.

The infestation examined by BERNARD was nearly finished, most of the galleries being empty and several already closed by wound tissue. But in Pangledjar the infestation was still in an active stage, and the galleries contained brood in various stages of development. In 1925, when the infestation on the Pamanukan Estates was discovered, the plants had already been pulled out at the nursery and a large number of them had been planted as stumps. The material submitted consisted of discarded plants which had been thrown on a heap. They showed old holes near the root collar and twice as many fresh galleries spread over the length of the plants and apparently made after the latter had been pulled out. Curiously enough in no instance were any parasites found in the tunnels.

It is also noteworthy that all the infestation reported apparently referred to tea plantations in the lower hills, no instance having come to notice of the occurrence of the borer in the extensive plantations on the Pengalengan Plateau, South of Bandung, at about 1000 m altitude.

5. *Swietenia* spp. (Mahogany)

The breeding of the small borer in mahogany (introduced from Central America) was first detected in seedlings grown under teak plantations, to raise a lower storey, in Subah, North Coast of Central Java, III.1915. The infestation was killing the plants and I soon found that the same borer also attacked seedlings of the two *Swietenia* species, *S. mahagoni* and *S. macrophylla*, in nursery beds and in natural regenerations, as well as, though less frequently, the lower twigs of the trees. These infestations apparently occurred in all the localities in the teak area where mahogany was used in pure or mixed stands (KALSHOVEN 1926).

Additional observations on the incidence of *morigerus* in mahogany, since made, have confirmed the preference of the borer for roots and stems of seedlings. From the point of view of silvicultural practice this is the most important feature.

Data on the size of the broods of the borer in mahogany have not been recorded before; therefore they are included in the table on p. 106.

6. *Tectona grandis* (Teak)

My first find of *X. morigerus* in teak concerned its occurrence in shoots, growing on stumps of recently thinned out young trees near Subah, IX.1918. In the same year a similar occurrence was reported from the forest range Ngarengan, near Mount Muriah and in subsequent years the little borer was observed in these suckers everywhere where a search was made for it in widely separated parts of the teak forests of Java (ALTONA 1926, p. 49, KALSHOVEN 1928, p. 609).

These shoots, 0.5—2 m in height, grow abundantly on the fresh stumps parti-

cularly in thinned-out stands. Most of the suckers grow slowly and several dwindle or die, especially when the bark and sapwood of the stumps are destroyed by termites. This infestation can be easily detected by discoloured patches in the pith of the twigs, when split with a knife.

After entering a young shoot the borer carves a gallery approximately in a horizontal plane, often following the outer margin of the broad, square pith. In older shoots the brood chambers are more irregular and are formed rather in a vertical plane in the wood cylinder. Ten and more holes may be found in one meter long sections, mostly in lower parts and not in tops which are covered with leaf scars. Normal broods are present in the tunnels in different months of the year, though no large ones (see table on p. 106).

The presence of a few holes in a shoot seems to have no apparent effect, but more frequent attacks will kill the top. However, these shoots often make new sprouts at a lower level. Old boreholes overgrown by the plant are a common feature. This indicates the borers select shoots which still have sufficient vigour for recovery.

Attacks on branches on the lower level of the crown of teak trees also occur but have been observed only rarely. It appears that these borings can lead to the withering of the leaves and eventually to a die back of the top of the branch.

After a circular letter had been sent in December, 1931 to the Forest Conservators in Java asking for information on the occurrence of *Xyleborus destruens* Bldf., the 4 mm long, near-primary shothole borer of teak, two of the reports received appeared to concern *X. morigerus*. In one case the infestation had been found in a poorly developed part of a 15-year old teak plantation in Ponorogo, East Java, II.1932. Little brown spots on the trunks where the beetles had made entrance holes, were found on some 30% of the trees, all suppressed and more or less dwindling specimens, about 8 cm in diameter. A further observation brought to light that thickly planted rows of *Leucaena glauca* in this plantation were heavily infested by the little borer, which had led to the death of several of the slender stems. In the teak trunks the galleries did not penetrate the wood for more than 10 mm. However, the discoloration of the wood, particularly in a vertical direction below and above the galleries was very marked.

In the other instance, observed in Padangan, in III.1932, the borer was found in a closely cropped 5—6 year old plantation awaiting its first thinning-out. Here it had only attacked backward specimens of the young teak stand. However, saplings of interplanted *Swietenia mahagoni* were infested up to 100% as was evident from the numerous exudations of gum from the bore holes.

In conclusion it can be said that teak can serve as an important breeding place for *X. morigerus* wherever shoots are sprouting from stumps, but that branches and trunks of young backward trees are attacked only in places where the borer has been building up a large population in other plants.

It has not been investigated whether the borer can also breed in the taproot and stems of teak seedlings in a natural regeneration, but this seems unlikely as the seeds germinate only in open and sunny places.

7. *Leguminosae*

a. *Leucaena glauca* Benth. — WURTH as well as DE LANGE (1909) published

short notes on the occurrence of 'X. *coffeae*' in 1—2 m high seedlings of "lamtoro", the much used shade tree in coffee plantations in East and Central Java. The infestation was found in a nursery on an estate South of Malang. The seedlings were suffering much, especially when several holes had been made in one plant. No holes occurred in stems of elder plants.

When the occurrence of the borer in the teak forest was being studied, *Leucaena* was noted as a common and important host plant in many localities. The infestation, however, is easily overlooked. In teak plantations the lamtoro is planted in dense rows or in hedges, for soil cover, prevention of erosion, and similar purposes. Little attention is paid to the plants so that the occurrence of diseased or dead specimens among the sparsely-built, backward plants remains unnoticed. When the hedges crop up too high they are simply cut down near the ground.

I made an investigation of some 50 stems from strongly infested rows, pruned some time previously, in a teak plantation near Kedungdjati, in II.1923. All stems, ranging in diameter from 2.5—12 mm, had well developed borer-holes, up to 9 in one plant. Some holes were already left by the beetles of the new generation, other were recently started by the mother beetle and contained rich ambrosia growth and brood in various stages of development (see table, p. 106). The smallest plants of 2.5—3.5 mm diameter had often a dead top or a dead portion in the stem near bore holes, or were killed altogether by even a single hole. Some plants had made new shoots at their base. There was some exudation of gum from a comparetively small number of fresh holes.

b. *Crotalaria* spp. — *C. anagyroides* H.B.K., a green manuring plant already long in use, was found to be a potential host of *morigerus* in V.1923, in the Experimental Garden at Bogor; soon the borer was received from this plant in other places in West Java, particularly infesting old specimens; similar breeding of the borer was also found in the Experimental Garden for coffee, Bangelan, East Java, in October, 1925. Investigations at coffee estates then showed that this infestation occurred in various degrees in all localities, in the same *C.* species and also in *C. usaramoensis* (Begemann 1926, p. 197, 230, 231). In some instances only old and too slenderly grown specimens were affected, but new shoots of pruned shrubs and even young green stems were attacked as well. In the infested stems examined the wood layer was 4—8 mm and the pith 2—3 mm, the shoots being 10—20 mm in diameter. It was observed that the beetles occasionally bored also into the taproot of the plants.

c. Other green manure plants. Begemann (l.c.) found in 1925 that another frequently used species, *Tephrosia vogelii*, was also being attacked by the borer and later *T. maxima*, occurring in the Experiment Station garden at Malang, XI.1929, was observed to be an occasional host (Schedl 1931). Abundant breeding of the borer in *T. vogelii* was reported from Deli, N.E. Sumatra, in 1936 (van der Goot, 1938 p. 84, Anon. 1941, p. 23).

d. A few other cultivated Leguminosae (*Albizzia, Centrosema, Derris*) are mentioned below under incidental and secondary attacks (p. 101). The only instance where I observed a wild leguminous shrub being attacked was in a teak forest near Gundih, C. Java, where "opo-opo" plants with broad leaves — probably *Flemingia strobilifera* — were killed by tunnels in stem and roots (III.1923).

8. *Sambucus*

Wilting twigs on native elder (*Sambucus javana* Reinw.) caused by the primary attack of *morigerus* were sometimes observed in Bogor. BETREM (1931b) stated that he found many more infestation of *Sambucus* by the brown species (*morigerus*) than by the black (*morstatti*) at the time the latter was spreading near Malang.

INCIDENTAL PRIMARY OCCURRENCE IN VARIOUS HOST PLANTS

(1) In small saplings of *Schleichera oleosa* planted in backward young teak stand; a few galleries also observed in the twigs of saplings of the same tree species in a young experimental plot, Semarang District, X.1918.

(2) In young plants of "uris-urisan", *Grewia laevigata*, in a teak forest in the same district, VI.1922.

(3) In seedlings of *Eusideroxylon zwageri* in natural regeneration of forests in S. Sumatra, only a few specimens of a small variety of *X. morigerus* found in the company of *X. morstatti,* which apparently was in the majority, 1924 (KALSHOVEN 1958b, p. 244).

(4) In the roots of seedlings of *Erythroxylon novagranatense,* Tegallega Estate, W. Java, XII.1924 (l.c., p. 246).

(5) A single specimen in the stem of an *Acalypha* shrub, other parts of the stem being occupied by *X. morstatti,* Botanic Gardens, Bogor, W. Java, II.1925 (l.c., p. 222).

(6) In a twig of a 4-year old sapling of *Altingia excelsa*, in a plantation near Tjidahu, Mount Salak, W. Java, 500 m, VI.1926.

(7) In seedlings of *Cassia multijuga*, showing a mixed infestation by *morigerus* and *morstatti*, Experimental Garden, Bogor, IX.1929, leg. VERBEEK (l.c., p. 222).

(8) In twigs of *Bixa orellana*, in forest plantations near Bandjar, W. Java, 1931 (leg. APPELMAN) and VII.1932.

(9) In "talingkub", *Claoxylon polot*, Bandjar, 1932.

(10) In the twigs of *Ochroma lagopus*, on the premises of the Forest Research Institute; larvae and pupae present, Bogor, IV.1932.

(11) Found as a twig borer of *Persea gratissima*, Tjirebon, W. Java, III.1938, and in the Experimental Garden Tlekung, Punten, E. Java, 900 m, IV.1941.

(12) In a twig of *Cinchona* tree in a plantation at Tapos, W. Java, 900 m, VIII.1940.

(13) In *Adenanthera pavonina*, Sampung near Ponorogo, E. Java, IV.1943, leg. SUDIRO.

(14) In a *Fuchsia* shrub, wilting as a result of the recent bore hole in the 7.5 mm thick stem; mother beetle not yet accompanied by brood, in a garden at Bogor.

(15) A rather severe infestation was found in the stem base of young specimens of the shade tree *Albizzia falcata*, which were shedding foliage, at a coffee plantation, outer slopes of Mount Kendeng, Besuki, E. Java. No other parasitic organisms were found in the plants, while this infestation did not occur on similar trees of coffee estates on the nearby Idjen Plateau, and so remained unexplained (ANON. 1938a).

Secondary infestation by xyleborus morigerus

(1) In parts of *Tephrosia vogelii* stems which were infested by the bark killing fungus *Corticium salmonicolor* (Roepke 1915, p. 18, borer erroneously called " *X. robustae*").

(2) In a small sapling of *Dalbergia latifolia* under the shade of a young teak stand, a few other saplings having succumbed as a direct result of unfavourable conditions, and some underplanted mahogany plants being affected in the same way; teak area of the Semarang District, X.1918.

(3) In multiple borer infested trunk of *Theobroma cacao*, Bogor, II.1924.

(4) In saplings of *Schleichera oleosa* killed by the *Corticium* fungus, in a forest plantation near Tegal, 15 ♀ and 2 ♂ being collected, VII.1920, and a dead specimen in its gallery of a few mm in the pith of a broken twig of the same species at Klangon, Mount Pandan, E. Java, V.1924.

(5) In dead stem of *Eupatorium pallescens*, Lembang, 1000 m, IX.1924 and in an old declining stem of the same species, Mount Gedé, Tapos, 800 m, VII.1932; in both cases in the company of other ambrosia beetles.

(6) In dying top of *Albizzia procera* branch killed at its base by *Corticium*; six holes in the sapwood, three of which still occupied by the borer (see table on p. 106); Forest Range Tanggung, Semarang District, XII.1924.

(7) Grafts of *Coffea* plants attacked and killed by the borer, although the grafting had been carried out successfully; the basal parts of stems with bore holes in two or three different places (Anon. 1927, p. 27).

(8) In senescent stalks of large Zingiberaceae growing along the forest border and in the ravines near Tapos, Mount Gedé, 800 m; in the company of other *Xyleborus* species; and similarly in dying stems of rattan palms, IX.1932, native collector (see Kalshoven 1935).

(9) During a search for borer infested plants and trees in the forests of the same locality, the native collector brought samples of "harendong minyak" (*Marumia muscosa*), "kanjere" (*Bridelia* sp.), "kiara" and "kiampelas" (*Ficus* spp.), "kipiit" (?), "nangsi" (*Boehmeria* or *Villebrunnea*), "salam" (*Eugenia polyantha*) and "saninten" (*Castanea argentea*) which were infested by various Scolytidae and Platypodidae, some of the parts containing a few specimens of *X. morigerus*, VIII—X.1933 (already listed by Schedl 1942).

(10) In experimental billets of *Tectona grandis*, left in the forest, which had also attracted other ambrosia beetles, Bandjar, VII.1933, 4 specimens.

(11) In a sapling of *Actinophora fragrans*, possibly killed by *Corticium*; teak forest in the Semarang District, IV.1933.

(12) In *Tectona grandis* infested by the same bark killing blight, *Corticium*, Forest Range Walikukun near Madiun, II.1935, 8 specimens.

(13) In recently planted and heavily attacked stumps of *Derris microphylla* on the Kalitelo Estate situated in the midst of the teak forests near Mount Muriah, E. Java, I.1929. All the stumps attacked were killed, including stems of 4 cm in diameter. The bore holes were found in the stems as well as in the roots.

(14) In *Cinchona* tree suffering from stem rust, Lampong District, S. Sumatra, VII.1938, 7 specimens of a small dark brown variety.

(15) A large number of *Centrosema plumieri*, used for soil cover on an estate

South of Malang, E. Java, reported to have been attacked by the brown twig borer in 1938; the plants recently weakened by being cut back close to the soil; the susceptibility of the plants being attributed to this condition (ANON. 1939b, p. 116).

UNSUCCESSFUL ATTACKS ON NORMAL HOST PLANTS

WURTH (1908) not unfrequently found tunnels in older sections of *robusta* stems not reaching the pith, and left by the borer. He concluded that apparently the wood had been too hard or too thick for the mother beetle to establish herself.

Similar observations were made by me on stems of mahogany plants grown to a size apparently no longer suitable for the breeding of the twig borer. In most instances the places with recently failed infestation were marked by crusts of gum and the unfinished galleries were empty. In a few cases where a brood chamber had already been formed the entrance of the gallery was plugged by sticky gum, the mother beetle killed, and the remnants of the brood embedded in the tainted ambrosia growth. Some time after an unsuccessful attack a small patch of dead bark with a hole in its centre would be formed, gradually detaching itself from the living tissue.

Similar reaction to boring wounds by the exudation of gummy matter was found in vigorous stems of *Leucaena glauca*. On the other hand empty holes were also found in slender *Leucaena* plants which had been succumbed so soon after the infestation that the ambrosia fungus could not have grown sufficiently to permit the raising of the brood.

As was stated in a previous paper (KALSHOVEN 1958a) unsuccessful attacks by *Xyleborus fornicatus* on its host plant *Schleichera oleosa* are also a common feature.

PLANTS UNSUITABLE AS HOSTS

When studying an insect with relatively polyphagous habits it is of equal importance to be informed about the plants which are more or less immune from the attack or unattractive as well as about those which are readily susceptible to the infestation. More or less incidental observations, giving useful indications in this respect, may be made in the field, and in my papers on *X. fornicatus* and *X. morstatti* I mention several instances of unsuccessful attacks on various plants in the outbreak centres of the borers (KALSHOVEN 1958a, p. 155, b p. 250).

WURTH (1908) had already contributed similar remarks with regard to *X. morigerus*. He found in coffee plantations traces of the borer's activities in twigs of the shade trees *Erythrina lithosperma* (Leguminosae) and *Melia azedarach* (Meliaceae), but no normal tunnels containing ambrosia growth and brood. In an adjacent plantation of the Cola tree, *C. acuminata* Schott (Sterculiaceae), imported from W. Africa, no signs of the borer were found at all. He correctly concluded that these plants were not suitable for the breeding of the borer.

WURTH also tried to breed the borer in some cultivated plants. When 80 beetles were placed on a young plant of *Myristica fragrans* Houtt. (nutmeg tree) he found that only one of them had succeeded in tunnelling right to the pith of the stem, while 24 beetles had only perforated the bark. The exudation of sap had apparently prevented them from entering deeper into the tissues. In *Hevea bra-*

siliensis Muell. and *Funtumia elastica* Stapf the beetles were prevented from tunnelling into the stem by the flowing of latex.

I made a few similar observations in the teak forests of Central Java. Traces of unsuccessful attacks have been found on saplings of *Enterolobium saman* Prain and *Pterocarpus indicus* Willd. (Leguminosae), growing in a mixed 4—5 year old plantation in association with *Tectona grandis* and *Swietenia mahagoni*; plants of the latter species furnished the main breeding place of the borer. On another occasion small unfinished holes were found in twigs of *Butea monosperma* Taub. (Leguminosae) and *Tarenna incerta* K. & V. (Rubiaceae). The absence of any trace of the borer on common trees like the mango and its allies, *Mangifera* spp. (Anacardiaceae), *Citrus* spp. (Rutaceae) and *Ceiba pentandra* Gaertn. ("kapok", Sterculiaceae), frequently found in the immediate neighbourhood of teak forests and coffee plantations in C. en E. Java, further indicates the unattractiveness of certain plant species to the twig borer. The pests of these plants are rather well investigated (Kalshoven 1951).

General survey of regular and incidental hosts

In order to facilitate the drawing of conclusions on some aspects of the ecology of the borer, the various data on its incidence mentioned in the previous paragraphs are tabulated here. All the plants found so far to be either potential hosts, possible hosts or incidental hosts are listed according to the same botanical system as used in the concise survey of "cultivated plants and weeds with their specific insects" in my book on the pests of Indonesian crops (1951, vol. 2).

Table 1. Systematic list of host plants of *X. morigerus* found in Java and Sumatra

Family, Genus, Species	Parts of the plants attacked			
	twigs and branchlets	stems, suckers, orthotropic branches	roots and stems of seedlings	weak plants or diseased parts
MONOCOTYLEDONES				
Zingiberaceae				
Amomum sp.? (honje)				× [1]
Palmae				
Calamus sp. (rattan)				× [2]
Orchidaceae				
Dendrobium, Vanda, Cattleya		× [3]		
DICOTYLEDONES				
Lauraceae				
Eusideroxylon zwageri T. et B.			×	
* *Persea gratissima* Gaertn.	×			
Fagaceae				
Castanea argentea Bl.				?×
Hamamelidaceae				
Altingia excelsa Nor.	(×)			
Bixaceae				
* *Bixa orellana* Linn.	×			
Theaceae				
* *Thea sinensis* Linn.			×	
Myrtaceae				
Eugenia polyantha Wight				?×
Melastomeceae				
Marumia muscosa Bl.				?×

Family Genus Species	Parts of the plants attacked			
	twigs and branchlets	stems, suckers, orthotropic branches	roots and stems of seedlings	weak plants or diseased parts
Tiliaceae				
Grewia laevigata Vahl.	(×)			
Actinophora fragrans R.Br.				×
Sterculiaceae				
* *Theobroma cacao* Linn.			×	×
Bombacaceae				
* *Ochroma lagopus* Sw.	(×)			
Erythroxylaceae				
* *Erythroxylon novagranatense* Hier.			×	
Euphorbiaceae				
Acalypha sp.	(×)			
Bridelia sp. (kanjere)				?×
Claoxylon polot Merr.	(×)			
Leguminosae				
Mimosoideae				
Adenanthera pavonina Linn.			?×	
* *Albizzia falcata* Back.				×
Albizzia procera Benth.				×
Caesalpinoideae				
* *Cassia multijuga*			×	
Papilionatae				
Butea monosperma Taub.	(×)			
* *Centrosema plumieri* Benth.				×
* *Crotalaria anagyroides* H.B.K.		×		
* *Crotalaria usaramoensis* Bak.		×		
Derris microphylla Val.				×
Dalbergia latifolia Roxb.		(×)		
Flemingia strobilifera R.Br.			×	
* *Leucaena glauca* Benth.			×	
* *Tephrosia maxima* Pers.		×		
* *Tephrosia vogelii* Hook.		×		
Moraceae				
Ficus spp. (kiara, ki-ampelas)				?×
Urticaceae				
Boehmeria or *Villebrunnea*				?×
Onagraceae				
* *Fuchsia* sp.		×		
Meliaceae				
* *Swietenia macrophylla* King	×		×	
* *Swietenia mahagoni* Jacq.	×		×	
Sapindaceae				
Schleichera oleosa Merr.	(×)			×
Rubiaceae				
* *Cinchona* sp.	×			
* *Coffea canephora robusta*	×	×		
* *Coffea liberica* Bull.	×			
* *Coffea excelsa* A. Chev.	×			
Tarenna incerta K. & V.	?×			
Caprifoliaceae				
Sambucus javanica Reinw.	×			
Compositae				
* *Eupatorium pallescens* Dc.				×
Verbenaceae				
Tectona grandis Linn.		×		

* not indigenous
1) in old declining stalks
2) in recently cut and dying stems
3) in the aerial roots, stems and pseudobulbs
?× accurate observations missing
(×) incidental cases

Some interesting points brought to light by this survey are the following: the number of more or less potential hosts of *X. morigerus* occurring as a primary borer, is rather limited: they include 18 species belonging to 14 genera and 13 families. Only three out of these species belong to the native forest flora, all other are imported in the course of time from other tropical countries, several being now grown in extensive plantations.

In a relatively large number of cases the borer or the traces of its primary attack were found only locally, in a single or in a few plants. These cases comprise introduced species not regularly used on a large scale, and native species growing scattered in teak forests. Particularly the latter cases make it likely that the borer in favourable circumstances occasionally occurs in many other plant species.

Although the stems of seedlings appear to have about the same structure as thin twigs the borer does not necessarily occur as a twig borer as wel as a seedling-stem borer of the same plant species. There is a striking difference in this respect between plants of *Coffea* and *Thea*. In coffee plants the borer never uses seedlings in nurseries as a breeding medium, while in tea plants on the contrary only seedlings are attacked and twigs of mature shrubs are not used at all. This is the more curious as the frame of tea shrubs is subject to attack of another primary ambrosia beetle, *Xyleborus fornicatus* Eichh.

Other points in relation to the selection of host species and of particular parts of the plants for breeding will be discussed in the final paragraph.

Size of the broods

The following table combines data on the composition of the broods found in cases of apparently successful breeding of the borer in different host plants. The rather fragmentary data, derived from some publications and from my own notes, are arranged in the same manner as applied in my previous papers on the ambrosia beetles of Indonesia (KALSHOVEN, 1958, 1959).

Table 2. Size and composition of brood found in galleries in various host-plants

Host plant	Part attacked	Mother beetle	Composition of the brood						Number of offspring
			eggs	larvae	pupae		young adults		
					♀	♂	♀	♂	
Coffea robusta	twigs and stems	1	11	40					51
		1	+	+	+				68
			+	+	+				72
		1		+	+				55
(data derived from WURTH 1908)		1		24			24	1	49
		1		28	36		5	3	72
		1		1			36	3	39
		1					29	2	31
		1					21	3	24
(samples from East Java, XI/XII 1924)	branch of 11 mm	1	6	19	6	1			32
		1		1	3		18	1	23
	branch of 15 mm	1		1	4	1	44	10	64
Thea sinensis (data derived from VERBEEK 1929)	roots of seedlings	1	24						
		1	14	4					
		1	13	8					
		1	7	12					
		1	26	20					46

Host plant	Par attacked	Mother beetle	Composition of the brood						Number of offspring
			eggs	larvae	pupae		young adults		
					♀	♂	♀	♂	
(data derived from VERBEEK 1929)	seedlings	1		3	16			1	20
		1		9	5		5	3	22
		1		12	6		3	1	23
		1		14	8		5	2	29
		1		7	16		17	1	42
		1		6	22		20	1	50
		1		12	27		15	1	55
		1		28	24		11	3	66
Swietenia macrophylla									
(teak-forest, Central Java VIII.1919)	seedlings	1		7	10	2	4		23
		1		4	2	1	13	3	23
		1		4	2		20	2	28
		1		3	1		11	1	16
Swietenia mahagoni (Bogor, I.1921)	twig	1		10	4	1	12	3	30
(teak-forest, Central Java, IV.1921)	seedlings	1	12	4					
		1		16					
		1	10	11					
		1	3	20					
		1	17	23					44
(the same, VII.1922)	seedling	1		21					
(the same, VI.1922)	twig	1		22					
Tectona grandis (Central Java, III.1923)	sucker, 6 mm	1	5	4					
	,, 8 mm	1		1	2		3		
	,,	1		6	5		1	1	13
	,,	1		8	6	2	1		17
	,, 12 mm	1					6	3	+)
Erythroxylon novagranatense (W. Java, XII.1924)	root of seedling	1		5	3	1			
		1		4			7	1	12
Leucaena glauca (teak-forest, Central Java, II.1923)	stems of young plants	1	10	12					
		1	8	15					
		1	1	1			8	1	
		1	1	7			6	2	16
		1	1				10	2	+)
Albizzia procera (C. Java, XII.1924)	wilting top	1	5	11	5				21
Dendrobium superbiens (Hawaii, after SWEZEY 1935)		1		11	10				21
		1		11	4		4		19
		1	3	26	14		3		47

*) A number of the young adults might already have left the gallery.

This table shows that the broods in branches and stems of *robusta* coffee present the highest figures, the number of young stages and adults amounting to more than 70 for a single gallery; the largest number of adults of the new generation actually found is 54.

Broods of fair size have also been found in tea seedlings and of somewhat smaller size, in mahogany seedlings and in *Dendrobium*.

There is some evidence that the suckers of teak stumps and the stems of young *Leucaena* provide a less suitable breeding medium for the borer.

Status of Xyleborus morigerus as a primary and secondary borer

From the extensive survey given (p. 94) it is evident that *X. morigerus* often finds conditions suitable for a primary attack on healthy plants of certain species, for instance in stems of well-cultivated orchids, in vigorous orthotropic shoots of coffee trees, in naturally sprouted seedlings of mahogany, etc. However, some observations have also shown that in some cases plants of the same host species can resist the attack of the borer, particularly so when the diameter of the attacked stems and branches is too large. On the other hand convincing proofs have accumulated of purely secondary occurrence of the borer in weak and diseased plants or parts of plants (p. 101). The striking infestation of seedlings on nursery beds must perhaps be attributed in part to unfavourable conditions for the plants as a result of crowding. Where *morigerus* occurs as a borer on high shrubs and trees it is remarkable that only twigs and branchlets on the lowest level of the crown are attacked.

Summing up it is not easy to decide whether *X. morigerus* must be classified as a near-primary phytophagous species showing its original secondary habits only occasionally, or that it must be considered in the first place as a secondary borer inclined to attack healthy plants only there, where it has built up a dense population.

With regard to these seemingly conflicting views the following opinions from the literature may be cited.

Roepke (1916) observed an outbreak of *morigerus* on an estate near Salatiga, where the coffee trees were producing an exceptionally heavy crop of berries. The greater part of the branches attacked at the time were on the verge of dying off. He was convinced that the trees had become susceptible to the infestation as a result of the heavy fruit-bearing and that the borer therefore had played a secondary role.

An increase of the twig borer damage was noticed in 1926 in coffee plantations in Central and East Java and was considered to be the after-effect of the drought of 1925 or a direct result of another particular dry season in 1926 (Anon. 1927, p. 27, Begemann 1927).

During extensive discussions on the increase of the twig borers in 1931 (mainly *X. morstatti*) stress was laid on the relatively high age of several *robusta* plantations, which might have made them less resistent to the borer damage (Kunemann 1931, Betrem 1931b, p. 1113).

Betrem repeatedly hinted in this and other papers at a possible correlation

between the twig borer infestation and the activity of root nematods. In 1951 he summarized the results of his long-continued observations, mainly concerning *X. morstatti,* as follows: "in (coffee) branches that are completely healthy the ambrosia cannot grow; it flourishes only in those which are more or less weakened; e.g., twigs of trees of which the roots are attacked by eelworms (*Pratylenchus pratensis* de Mann) ..... are especially severely infested by the beetle." ..... "Statistical studies have shown, that the only branches heavily attacked are those that are weakened and would in any case die by natural causes in a short time. The *Xyleborus* beetles are therefore secondary pests of the coffee."

BERNARD (1919) reporting for the first time about the infestation of seedlings of tea on nursery beds specified that the plants belonged to a weak type.

Nematods were found at the roots of tea plants in the same nurseries of an estate in C. Java where the borer infestation was found in 1929 (p. 96).

In Deli, N.E. Sumatra, the twig borer *Xyleborus morigerus,* the nematod *Heterodera radicicola,* and a root fungus *Rigidoporus* were listed simultaneously as pests of *Tephrosia vogelii* (VAN DER GOOT, 1938). However, in these cases no special correlation was mentioned between the borer infestation and the occurrence of other organisms.

In connection with the death of mahogany seedlings in a natural regeneration under high forest as a result of stem borer attack by *morigerus,* KALSHOVEN (1925, 1926) expressed the opinion that the borer was particularly eager to attack plants in which the growth in the height — the forming of a new top shoot — had temporarily come to a standstill, the osmotic pressure therefore being at a low level.

All these opinions agree in the consideration of *X. morigerus* as principally a secondary borer, nearing occasionally the status of a sub-primary species.

In concluding this study the following characteristic of the species may be presented: *Xyleborus morigerus* is a specific borer of twigs and stems of small diameter, very often measuring only 5 mm and in no case thicker than 15 mm.

The species is able to attack very different plant species, even including a few herbaceous Monocotyls. It often finds suitable conditions in plantations of non-indigenous plants. However, an equally large number of plant species is not attractive to the borer.

In some cases it breeds in plant parts which are infested by blight, particularly the bark-destroying *Corticium salmonicolor*; often it can be found in old, declining stems and branches, as well as in temporarily weakened plants like stumps, grafts, transplants, and in plants affected by drought, over-bearing, root nematods, etc. Still, the borer has a definite tendency to a near-primary occurrence in living plants.

It appears to be limited in its occurrence to the low vegetation strata, like undergrowth, seedlings under high forest, the lowest crown branches, and not seldom it enters the ground to attack tap-roots.

By breeding in stems, aerial roots and pseudobulbs of orchids, it has been transported, and is still being transported, all over the world; in temporate climates it can live on in hothouses.

REFERENCES

ANONYMOUS, 1898. "AN Orchid beetle (*Xyleborus perforans* Woll.)". Journ. Board Agric. 4, p. 474.

———, 1907. Notulen der Alg. Vergad. v. d. Kedirische Landb. Vereeniging van 21 April 1907.

———, 1907. Notulen v. d. op 31 Aug. 1907 gehouden Alg. vergad. v. d. Malangsche Landb. Vereeniging.

———, 1919. Jaarboek v. h. Depart. Landb., Nijverh. en Handel, 1918.

———, 1927. „Verslag over het jaar 1926". Meded. Proefst. M. Java, nr. 44.

———, 1939a. „Jaarverslag v. h. Besoekisch Proefstation over 1938". (mimeographed).

———, 1939b. „Verslag v. d. werkzaamheden v. h. Proefst. M. en O. Java over 1938". (mimeographed).

———, 1941. „Verslag v. d. Directeur v. h. Alg. Proefst. der A.V.R.O.S. over het tijdvak 1 Jan. 1937—31 Dec. 1939". Meded. A.V.R.O.S. Proefst. Medan nr. 59.

ALTONA, F., 1926. „Aantasting van *Tectona grandis* L. (djati) door *Corticium salmonicolor* B. et Br. (djamoer oepas)" Tectona 19, p. 31.

BEGEMANN, H. 1926. „Verslag v. d. Entomoloog over het tijdvak December 1924—1925". Arch. Koffiecultuur, 1, p. 194.

———, 1927a. „Verslag v. d. Entomoloog over het jaar 1926". Arch. Koffiecultuur, 1, p. 273.

———, 1927b. „Takkenboeboek van de koffie (*Xyleborus morigerus* Blandf.)". Bergcultures 2, p. 329.

BERNARD, Ch., 1919. „*Xyleborus* aantasting". Meded. Proefst. Thee nr. 68.

BETREM, J. G., 1930. „Koffie en insecten". Bergcultures 4, p. 1012.

———, 1931a. „Een en ander over de takkenboeboek". Bergcultures, 5, p. 404.

———, 1931b. „Enkele opmerkingen over den takkenboeboek en zijn schade". Bergcultures 5, p. 1100.

———, 1931c. „Ambrosia kevers". Handel. 6de Ned. Ind. Natuurwet. Congres, p. 440.

———, 1933. „De takkenboeboek als veroorzaker van takkensterfte". Bergcultures 8, p. 73.

———, 1938. „Takkensterfte, takkenboeboek en snoei in verband met productie bij koffie". Bergcultures 12, p. 476.

———, 1952. "Interrelation and interaction of biotic and abiotic factors in some tropical insects". Trans. Ninth Int. Congr. Ent., vol. 1, p. 791.

BLANDFORD, W. F. H., 1894. "Notes on Scolytidae and their food-plants". Insect Life 6, p. 260.

BLEIJ, 1907. (Remark during discussion). Cultuurgids 9, p. 703.

CHOBAUT, A., 1897. "Sur un *Xyleborus* parasite d'une Orchidée des serres Européennes". Ann. Soc. Ent. Fr. 66, p. 261.

CRAMER, P. J. S., 1908. In: Jaarboek Depart. Landb., Nijv. en Handel voor 1907.

FRANSSEN, C. J. H. en L. M. J. TIGGELOVEND, 1935. „De vijanden en ziekten van de Orchideeën op Java en hunne bestrijding". Batavia.

GARRETSEN, A. J., 1926. „Enkele aanteekeningen over theekweekerijen". De Thee 7, p. 130.

GOOT, P. VAN DER, 1938. „Ziekten en plagen der cultuurgewassen in Ned. Indië in 1937". Meded. Inst. v. Plantenziekten (mimeographed).

HALL, C. J. J. VAN, 1912. „Gegevens over *robusta* en aanverwante koffiesoorten". Teijsmannia 23, p. 620, 741.

HUNGER, F. W. T., 1907, 1908. „Verslag omtrent den Staat v. h. Alg. Proefst. te Salatiga over het jaar 1906". p. 28. Idem 1907, p. 35, 55, 68, 129, 131.

KALSHOVEN, L. G. E., 1925. „Primaire aantasting van houtige gewassen door *Xyleborus*-soorten". Verslag Zesde Vergadering Vereen. Proefst. personeel.

———, 1926. „Beschadigingen, ziekten en plagen van mahonie (*Swietenia mahagoni* and *S. macrophylla*) op Java". Meded. Inst. Plantenziekten, nr. 69.

———, 1928. „De beschadigingen, ziekten en plagen van de djatibosschen op Java". Tectona 21, p. 593.

———, 1935. „Boeboek-kevertjes (Scolytidae) in Zingiberaceae, grassen en rotan.stengels". Entom. Meded. Ned. Indië 1, p. 13.
———, 1951. „De plagen van de cultuurgewassen in Indonesië". Deel II, p. 847.
———, 1958a. "*Xyleborus fornicatus* Eichh. as a primary and secondary shot-hole borer in Java and Sumatra". Entom. Berichten 18, p. 147, 185.
———, 1958b. "The occurrence of the primary twig-borer, *Xyleborus morstatti* Hag. in Indonesia". Entom. Berichten 18, p. 220, 244.
———, 1959a. "Studies on the biology of Indonesian Scolytoidea, 4. Data in the habits of Scolytidae. Second Part". Tijds. v. Entom. 102, p. 135.
———, 1959b. "Dr. A. Zimmermann's Java Scolytids identified". Entom. Berichten 19, p. 224.
KEUCHENIUS, P. E., 1915. „Verslag over het jaar 1914". Meded. Besoekisch Proefst., nr. 17.
KUNEMAN, J. H., 1931. Lezing over takkenboeboek. Bergcultures 5, p. 1077.
LANGE, D. DE, 1909. „Robusta-boeboek in Cacao pépinières". Cultuurgids 11, p. 986.
LEEFMANS, S., 1923. „De koffiebessenboeboek (*Stephanoderes hampei* Ferrari = *coffeae* Hagedorn). I. Levenswijze en Oecologie" Meded. Inst. v. Plantenziekten, nr. 57.
———, 1928. „Takkenboeboek als bessenboorder". Bergcultures 2, p. 294.
MULLER, H. R. A., 1933. „Ambrosia-schimmels van tropische Scolytidae". Verslagen Afd. N.O. Indië v. d. Ned. Entom. Vereen. 1, p. 105, 125.
ROEPKE, W., 1915. „Verslag over het jaar 1914—1915". Meded. Proefst. Midden Java, nr. 20.
———, 1916. „Verslag over het jaar 1915—1916". Meded. Proefst. Midden Java, nr. 23.
———, 1917. „Cacao".
SCHEDL, K. E., 1931. "Notes on the Genus *Xyleborus* Eichh.". Ann. Mag. Nat. Hist., ser. 10, vol. 8, p. 339.
———, 1942a. „Interessante und neue Scolytiden und Platypodiden aus der austral. Region". Mitt. Münch. Ent. Ges. 32, p. 162.
———, 1942b. „Neue Scolytiden aus Java". Tijds. v. Entom. 85, p. 1.
———, 1955. „Borken- und Ambrosia-Käfer aus dem pazifischen Raum". Entom. Arbeiten a. d. Mus. Frey, 6, p. 277.
SWEZEY, O. H., 1935. "*Xyleborus morigerus* obtained from stems of *Dendrobium superbiens*". Proc. Haw. Ent. Soc. 9, p. 6, 108.
VERBEEK, F. A. Th. H., 1930a. „Kiemplant-boeboek in thee". Bergcultures 4, p. 402.
———, 1930b. „*Xyleborus morigerus* Blandf. als kiemplant-boeboek". Arch. Theecultuur in Ned. Indië, nr. 3.
WICHMANN, H. E., 1954. In BLUNCK. Handb.d. Pflanzenkrankheiten. V. Coleoptera.
WIGMAN, H. J., 1909. „Orchideeën. Het geslacht Dendrobium". Teijsmannia 20, p. 564.
WURTH, Th., 1907a. „Boeboek in de Robusta koffie". Cultuurgids 9, p. 96.
———, 1907b. „Heeft *Coffea robusta* een grooter weerstandsvermogen tegen ziekten en plagen dan *Coffea arabica* en *Coffea liberica*?". Cultuurgids 9, p. 708.
———, 1908. „De boeboek (*Xyleborus coffeae* n.sp.) op *Coffea robusta*". Cultuurgids 10, p. 63.
———, 1909. „Lamtoro aangetast door de Robusta-boeboekkever". Cultuurgids 11, p. 548.
———, 1910. „Verdere mededeelingen over den Robusta-boeboek (*Xyleborus coffeae*)". Cultuurgids 12, p. 101.
———, „Jaarverslag over 1915". Meded. Proefst. Malang, nr. 12.
———, 1921. „Verslag omtrent de werkzaamheden van het Proefstation Malang over 1920". Meded. Proefst. Malang nr. 34.